Contextualisation and evaluation of novel sonic interfaces using problem based learning

Nordahl, Rolf; Serafin, Stefania; Timcenko, Olga

Published in:
Proceedings CHI 2008 Workshop on Sonic Interaction Design

Publication date:
2008

Document Version
Publisher's PDF, also known as Version of record

Contextualisation and evaluation of novel sonic interfaces using problem based learning

Rolf Nordahl
Medialogy,
Aalborg University
Copenhagen
Lautrupvang 15, 2750
Ballerup, DK
rn@media.aau.dk

Stefania Serafin
Medialogy,
Aalborg University
Copenhagen
Lautrupvang 15, 2750
Ballerup, DK
sts@media.aau.dk

Olga Timcenko
Medialogy,
Aalborg University
Copenhagen
Lautrupvang 15, 2750
Ballerup, DK
ot@media.aau.dk

ABSTRACT
In this paper, we advocate the use of problem based learning (PBL) as a pedagogical method in educations addressing the design and evaluation of sonic interfaces. We introduce two projects as examples which adopt PBL in the design of sonic interactive systems, and we discuss our approach in combining contextual and technical issues in interaction design.

The challenge becomes therefore not *how* to design interactions, but *what* to design and especially *why* to design interactive systems. More specifically, it is the *why* which leads to the *how* and the *what*.

Author Keywords
Problem based learning, interaction design.

ACM Classification Keywords
H.1.2 Information Technology and Systems: User/Machine Systems; H.5.2 Information Interfaces and Representation (HCI): User interfaces

INTRODUCTION
The design and implementation of interactive systems does not represent anymore a challenge from the engineering perspective. Nowadays, different microprocessors are available in the market, which allow to easily connect several sensors. Moreover, software platforms such as Max/MSP from Cycling 74[1] or Processing[2] allow to easily capture the data sent by such sensors, and process them in real-time.

The problem based learning (PBL) approach adopted at Aalborg University is a pedagogical method which trains students to become problem solvers and not task solvers [6].

In the pedagogical system developed at Aalborg University, each semester has a theme. Such theme is supported by several courses, known as project supporting courses (abbreviated as PE courses in danish). All students, working in groups, develop along the semester a project which is related to the theme and uses knowledge and experience obtained following the courses.

[1]www.cycling74.com
[2]www.processing.org

In the Medialogy education at Aalborg University in Copenhagen, we adopt the PBL approach since it allows students to address the contextual implications in the design of interactive systems. The main distinguishing feature of the PBL approach is not the fact that students are working on a semester project, which is now a common practice in different educations.

Students are introduced to different technical and contextual subjects during the semester. Along the semester, they are asked to formulate a problem which addresses issues covered in the semester. Students are therefore asked to become problem solvers rather that product developers, and the products developed become a solution to the problem.

Another important issue in the design of interactive system is how to evaluate that the problem has been properly addressed. This issue becomes especially critical when the application designed has an artistic connotation. We experiences that some of our students interests in interactive media art do not feel the need to justify or contextualize their realizations.

However, we believe that PBL allows freedom to express students willingness to create an artistic product as well as academic rigour which derives from the evaluation techniques adopted to assess such product.

In this paper, we introduce two projects implemented during the Spring semester 2007 in the 4th Semester of the Bachelor Medialogy education at Aalborg University in Copenhagen under the theme *Interaction Design*. These projects are quite different in the problem they address and the application developed, but we believe they represent two successful examples of students' realizations under the interaction design theme.

Students learned how to design and build new interfaces embedded with sensors. At the end of the semester, they built physical objects which could be touched, squeezed, moved around, and which sent information of such actions to the computer. Students also acquired skills in sound design and how to program sound effects. Moreover, they learned about design principles, usability studies and evaluation techniques for interaction design.

Three sub-themes for projects were suggested: sound in games, alternative musical instruments and sound in products. Students were divided in groups of 5-6 people each and asked to find problems related to the design of a physical interface embedded with sensors, with auditory feedback, and evaluated using usability techniques.

PBL AND INTERACTION DESIGN

As also observed in [8], PBL and interaction design share many characteristics, the most prominent of which is how to explore, analyse and define the problem space, the importance of teamwork and team development and, finally, creativity to design and find a solution.

The problem space, domain and context have to be analysed, and problem definition and requirements need to be defined. Team members have different roles, which must be clear to all. A team working together is much more powerful than individuals working alone. In teamwork both inter-personal and intra-personal skills [4] are important.

Brainstorming and creative work in a free and open atmosphere induce innovative ideas and solutions. The learning/design process is iterative, and a somehow structured process is necessary in order to deliver in due time.

THE SOUNDGRABBER

Problem formulation

The problem addressed by the installation called *The Soundgrabber* was to investigate the possibility of making sound tangible by means of an untangible user interface.

The New Oxford English Dictionary defines tangible as *anything which can be grasped either with the hand or the mind.* The aspiration of this project is to challenge the physical impossibility of designing an untangible application which creates the illusion that people are tangibly interacting with sounds. To our knowledge, no currently existing sound installations or physical interfaces evolve around the notion of making sound appear tangible in the relative sense previously described. The majority of the encountered applications and accompanying documentation related to the tangibility of sound seem to be centered on the manipulation of the parameters of sounds by influencing or displacing various representative physical objects as e.g. the tabletop tangible musical interface reacTable[5].

Other interfaces enable interaction with sound by means of an intangible interface as e.g., the *free gesture instrument* the Theremin, said to be the first of its kind, but as in the case of the tangible interfaces the main focus is the manipulation of the parameters of the sound rather than virtual relocation of the sound.

Before starting the actual design of the interface, different museums were visited. This was done to analyze similar projects and explore their intended target audience, usability and design principles.

In particular, the Experimentarium in Copenhagen[3] and the Museum of Contemporary Art in Roskilde[4] were visited. The Experimentarium is an interactive sound museum mostly for elementary school children. Lots of pedagogical installations are featured, and quite a few of them are related to interacting with sounds. One interesting example are sound boxes developed by researchers from the University of Aarhus. In such boxes users can record, manipulate and re-assemble sounds produced by everyday objects, in order to create acousmatic compositions [2].

As also pointed out by the developers of the installation, the recording of everyday sounds was natural and intuitive, but the manipulation and arrangement was too complex to be performed by children. On the other end, the Modern Art Museum in Roskilde required a different target group, and showed a more limited audience.

The visit to different locations exhibiting interactive installations provided useful guidelines for the design of the Soundgrabber, among which the importance of natural interaction and simplicity in the design.

Implementation

As can be seen in Figure 1, the Soundgrabber is a physical interface designed as a semi-circle. At the top of the semi-circle, four columns are placed. At the bottom of each column a speaker is installed. Each column is embedded with light sensors, which allow to detect the position of the hand of the user moving vertically parallel to the column. Moreover, a bucket is placed in the center of the semi-circle. The user interacts with the Sound grabber using a glove embedded with a bend sensor. By bending the hand inside the bucket, the user is able to grab a sound, listen to it (thanks to the speaker embedded inside the glove) and release it in one of the columns.

The sensors are connected to a microprocessor developed by Making Things.[5] All the sounds which the user interacts with are synthesized in real-time using the Max/MSP platform. The Soundgrabber is therefore an interactive installation where users can grab different sounds and place them in different locations.

Evaluation

The project was evaluated by allowing users to play with it, and then answering a questionnaire inspired by the sensory substitution presence questionnaire, based on a 1 to 5 Likert scale [1]. In such questionnaire, statement such as "I felt that I was able to grab a sound" or "I felt that I was able to relocate the individual sounds" were made, and subjects were asked to answer in a scale from 1 to 5 if they agreed or not with the statement. Results showed that the sensory substitution between audition and touch worked, since there was a statistically significant amount of subjects who felt they were able to move sounds around and grab them.

[3] www.experimentarium.dk/

[4] www.mfsk.dk/

[5] www.makingthings.com/

Figure 1. Top: the Soundgrabber, bottom: the graphical user interface.

As part of the test, students wanted to understand for what kind of venues users thought the Soundgrabber was more appropriate. In particular, they wanted to understand in which of the previously visited venues (Experimentarium and Museum of Contemporary art) the installation could be exhibited. Test results did not provide a significant indication in any of the two directions.

During the testing in the lab, a graphical user interface shown in the bottom of Figure 1 was used. This was done in order to facilitate the user in easily identifying the location of the different sounds, and understanding which sounds were activated.

Being an art installation, Soundgrabber was also publicly demonstrated at the Sound Days event in Copenhagen in June 2007. In this situation, no graphical user interface was used.

Sound experts and naive visitors tried the installation, and provided enthusiastic feedback. We noticed how visitors were able to grasp the behavior of the interface quite easily, after few minutes of instructions. We also appreciated the fact that the lack of the graphical user interface enabled visitors to focus on the actual sounds and virtual touch. Figure 2 shows two of the developers and a visitor playing with the interface at the event.

From August 2007 to December 2007, the Soundgrabber was installed in the lobby of the Plex theater in Copenhagen.

Figure 2. The Soundgrabber was publicly displayed at the Sound Days event in Copenhagen in June 2007.

In designing the Soundgrabber, the PBL approach helped the students thinking about sound in a different ways. They were particularly interested in understanding to what degree sound can be made perceived as tangible. So PBL helped students to shift from the mere design of a musical installation to the desire to answer a scientific question.

WOBBLE ACTIVE

Problem formulation

A wobble board, shown in Figure 3, is a device for ankle rehabilitation after an injury. It is documented [3] that exercising on a wobble-board is a very efficient way to rehabilitate ankles, both after a sport injury or after any other kind of ankle injury. The issue is that the wobble-board training is quite boring, and patients tend to neglect it, as soon as they stop feeling physical pain although prolonged exercises are critical for successful rehabilitation. The main idea of this project is to use a wobble board as an input device for a computer game, as there are indications that playing games would increase motivation of doing otherwise boring exercises [7].

Testing the initial design idea

An initial testing, before the building of the prototype, was carried out on a group of test-persons that theoretically falls within the WobbleActives intended target group. The main goal of that test was to inform about the potential interaction-abilities with the gaming-interface while standing on the classic wobble board. Test persons were asked to balance on a wobble board while simultaneously following a moving object on a screen. The second goal was to test if there was any major difference in having an interface projected on a bigger canvas or if a computer screen would be enough.

12 persons were used for the test, and overall test results were encouraging. In spite of test persons different balancing skills, majority of them did not have significant difficulties in following the pattern on the computer screen while balancing. Majority also preferred computer screen over a large projection canvas.

Implementation

The main technical idea of the project realization is that with a help of 4 bend sensors[6] fastened to the bottom surface of a wobble board it is possible to measure inclination of the board in space, and to map those inclination into mouse movements on 2D screen.

A functional prototype of the wobble board, called WobbleActive, was produced, together with two tested games enhanced with interactive auditory feedback. In order to develop arcade games that would encourage proper exercising needed for rehabilitation, cooperation with a physiotherapist was established during the project. His role was to give expert advices on type of movements needed for proper ankle exercising. During development, the prototype games were tested several times in order to adjust for proper wobble board sensitivity. The games were developed with different levels of difficulty, with recording and memorizing scores, in order to keep users interest and motivation and allow for feeling a sense of progress. The final prototype was tested on 6 persons, and although this is a small number for final conclusions, the results on usability and motivation side were encouraging.

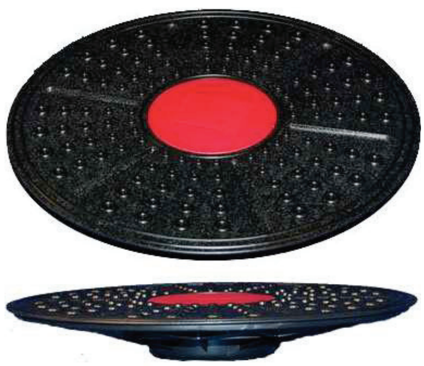

Figure 3. The original Wobble board used in the project.

Developing the games

The main objective for a wobble board user is to strengthen the ankle joints by use of some exercises determined by professionals. With that in mind, it is important that the exercises/movements intended for the user are maintained while playing computer games using WobbleActive. Therefore, two games have been designed based on the original wobble board exercises. It is important to emphasize that any number of games, using any theme, can be applied to the WobbleActive application depending on the target audience.

The two designed games were called Balance O Meter and The Maze respectively. A screenshot from the games is shown in Figure 4.

The main goal of Balance O meter is to keep within the designated area of the screen (keeping equilibrium on the wobble board) for as long as possible. On the contrary, the Maze game encourages left-right and front-back ankle movements, as the path needs to be fould in the maze. It is also important to motivate the user and allow him/her to have some kind of measurement of success within the games. Therefore healthbars were introduced to both games. Ideally both of these can be used to indicate ankle improvements following exercises.

During the games development, several small user tests were conducted, to fine-tune sensitivity of the interface. That is how two seconds for hovering (clicking) were determined, as well as how sensitivity on different game levels was chosen.

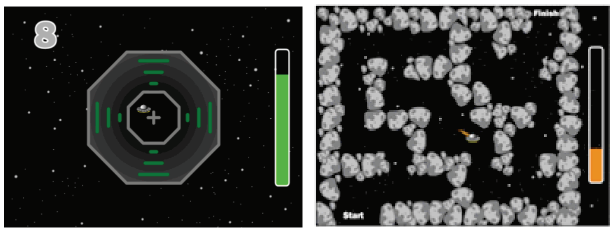

Figure 4. Screenshots from Balance O meter and Maze games

Menu navigation

A menu system is normally controlled using a mouse, keyboard or other controller such as a gamepad on consoles. We had the option to simply let the user use the computers mouse to choose games etc., but that would require moving back and forth between the mouse and the board, which can be annoying and distracting for the user. Instead, we wanted to enable the user to navigate the menu system using the wobble board itself as a controller. The interface menu is constructed to require only a small amount of decisions to accomplish a goal making it as easy as possible for the user to navigate.

The pre-game menu structure is only two levels deep; the first being game selection and the second a selection of the difficulty level. After each game, there is a possibility to play the same game again, on either the same difficulty setting or choosing a new, or to return to the main menu. The simplicity of the menu is especially important for this interface since the movements on the board control the cursor and it would easily become tiresome for the user if the menu was very complex and had many levels. In the worst case, it could result in the user giving up before even reaching the actual games. The obvious problem with the navigation was

[6] In this specific case, bend sensors were provided by: www.imagesco.com/sensors/flex-sensor.html

that there is no way the user can activate a button on the interface by the use of the wobble board since it only provides left/right and up/down movements. Forcing the user to hold a mouse in hand or similar to perform actions would be inconvenient and could hinder balancing. The solution to this was the hover sensitive buttons. This means that, in order to activate a menu item, the user has to hover the arrow over the button for two seconds.

The two-seconds hover delay was implemented to prevent accidental activation of buttons, since precisely controlling the arrow on screen by the use of the board can be rather difficult. The delay thereby enables the user to move away from the button before it activates if needed. Figure 5 shows the two seconds activation of a button. On the left image the user has just started hovering the cursor over the button, on the middle image the user has hovered for approximately one second and on the right image the button is activated.

Figure 5. Activating a button while hovering on it in Wobble Active user interface.

Auditory feedback

The auditory feedback in the games was created and implemented using Max/MSP. Different sounds with different objectives were created, from simple background music to interactive sonification of different actions of the player.

In particular, interactive sonic feedback was provided to facilitate equilibrium of the subjects using the board. More specifically, the orientation of the board was continuously sonified and mapped to a friction physical model [9]. The parameters of the model were varied according to the motion of the subjects.

When the subject was in equilibrium on the board, the corresponding friction sound was produced by parameters of the resonator in almost harmonic relationship. Moreover, low values of velocity and force of the friction model produced a sound which can be described as ”calm” and ”pleasant”. On the other end, when the subjects were in instable equilibrium, the friction sound was providing annoying auditory feedback, obtained by having strongly inharmonic resonators with high values of friction velocity and force.

Informal tests showed that the auditory feedback helped subjects to pay more attention to balancing on the board. We are currently running more formal usability tests to achieve a better understanding of the relationship between auditory feedback and balancing tasks.

In theory, WobbleActive could be used as an alternative controller to various computer-interaction functions, similar to a mouse or a gamepad. However, it lacks one important feature to that role, which is an active function equivalent to the mouse click. The hovering method was used in the WobbleActive games to rehabilitate ankles, and it completely solves this problem for those purposes. However, the method is not practical when fast interaction is required.

Figure 6. Top left: top view. Top right: side view. Bottom left: WobbleActive in action. Bottom right: the underside.

Test results indicate that WobbleActive can be used both for keeping motivation while exercising on the wobble board, but also as an interesting test-bed for new game interfaces and sound feedback.

In this project, the PBL approach allowed students to shift from the mere task of designing an alternative game interface to the desire of making the act of rehabilitating more entertaining.

CONCLUSION

In this paper, we introduced two projects which addresses sonic interaction design from different perspectives, although using similar technologies. We find that the PBL approach helps students structuring their project work, facilitating them in the formulation an initial problem, which is then solved by designing an interface embedded with sensors tested using standard usability techniques.

Several interdisciplinary educations and research projects addressing interaction design are appearing in different locations worldwide. Especially when different disciplines are involved, it is hard to maintain a coherent identity in the institution. We believe that PBL allows us to reach the goal of having such identity, and allows students and faculty members to address not only technical problems involved in designing interactive systems, but also contextual issues as well as evaluation techniques.

Why is PBL better?

REFERENCES

1. F. Biocca, J. Kim, and Y. Choi. Visual Touch In Virtual Environments: An Exploratory Study of Presence, Multimodal Interfaces, and Cross-Modal Sensory

Illusions. *Presence: Teleoperators & Virtual Environments*, 10(3):247–265, 2001.

2. M. Breinbjerg, O. Caprani, R. Lunding, and L. Kramhøft. An Acousmatic Composition Environment. *Proceedings of the 2006 conference on New interfaces for musical expression*, pages 334–337, 2006.

3. C.A. Emery, J.D. Cassidy, T.P. Klassen, R.J. Rosychuk, and B.H. Rowe. Effectiveness of a home-based balance-training program in reducing sports-related injuries among healthy adolescents: a cluster randomized controlled trial. *Canadian Medical Association Journal*, 172(6):749–754, 2005.

4. H. Gardner. *Frames of Mind: The Theory of Multiple Intelligences*. Basic Books, 1983.

5. S. Jordà, M. Kaltenbrunner, G. Geiger, and R. Bencina. The reacTable*. *Proceedings of the International Computer Music Conference (ICMC 2005), Barcelona, Spain*, 2005.

6. A. Kolmos, L. Krogh, and F.K. Fink. *The Aalborg PBL model: progress, diversity and challenges*. Aalborg University Press, 2004.

7. E.A. Locke and G.P. Latham. Building a practically useful theory of goal setting and task motivation. *American Psychologist*, 57(9):705–717, 2002.

8. N. Schultz and H.P. Christensen. Seven-step problem-based learning in an interaction design course. *European Journal of Engineering Education*, 29(4):533–541, 2004.

9. S. Serafin. *THE SOUND OF FRICTION: REAL-TIME MODELS, PLAYABILITY AND MUSICAL APPLICATIONS*. PhD thesis, stanford university, 2004.